

Correspondence

The sternalis muscle in the Bulgarian population: classification of sternales

The sternalis muscle (*musculus sternalis*) is the name usually given to this common anatomical variant, but the terms ‘episternalis’, ‘presternalis’, ‘sternalis brutorum’, ‘rectus thoracis’, ‘rectus sterni’, ‘superficial rectus abdominis’ and ‘japonicus’ have also been used in the literature (for reviews see Le Double, 1879; Calori, 1888; Pichler, 1911; Bles, 1968). According to Turner (1867), Cabrolus was the first, in 1604, to describe sternalis. Nevertheless this muscle is often unknown even in clinical practice (Bailey & Tzarnas, 1999; Vandeweyer, 1999).

Thus far, investigations on the incidence of sternalis have been made both in large populations such as the American (Barlow, 1935) and small populations, for example in Taiwan (Shen et al. 1992; Jeng & Su, 1998). In Europe, all studies on the frequency of this muscle have been made amongst subpopulations in Western (e.g. Cunningham, 1888; Le Double, 1890, 1897) and Northern Europe (Gruber, 1860) although the reported frequencies have been quite different. There is a lack of information about sternalis in Eastern European populations. We therefore present data from a study on the incidence of sternalis muscle in Bulgaria.

Over a 20 y period, 3 cases with sternalis muscles were found among 102 formol-carbol fixed cadavers. Two were small unilateral muscular bands, attached to the sternum and the pectoral fascia. In the third (which we describe here), a bilateral well defined muscle was detected during routine dissection of a female cadaver (Fig. 1*a, b*). Both muscle bellies (left and right sternalis muscles) were clearly visible under the skin and subcutaneous connective tissue, covered by a thin layer of the superficial fascia of the anterior thoracic region. The muscles originated from the

manubrium with well defined tendons which were continuations of the sternal tendons of sternocleidomastoids. Both sternales were located approximately parallel with the sternum so that the medial points of their distal ends were separated by 3.3 cm. The insertions of the muscles wove into the pectoral fascia, with some fibres attaching to the costal cartilages.

The right sternalis was larger than the left and had a length of 14.4 cm (from the jugular notch to the distal insertion) and a maximal width of 2.6 cm. It was located on the sternal end of the right pectoralis major. The muscle belly extended into a thin flat tendon. It inserted as an oblique line, directed inferolaterally from the pectoral fascia proximally, reaching the 4th and 5th costal cartilages distally.

The smaller left sternalis measuring 12.0 cm in length and 1.5 cm in width was situated along the left sternal margin, partly covering it. The lateral side of this muscle continued into a wide flat tendon attaching into the pectoral fascia at the level of the 3rd and 4th costal cartilages.

Both sternalis muscles were supplied by perforating branches of the internal thoracic arteries and were innervated by anterior branches of the intercostal nerves, which passed through or lateral to the muscles and ended as anterior cutaneous branches.

This is the first study to evaluate the incidence of the sternalis muscle in the Bulgarian population and is the first report on the frequency of this muscle in Eastern Europe. The frequency of the muscle in Bulgarians on the basis of our study (3 cases in 102 cadavers) is 2.9%. This value is in the range reported by other investigators for different populations, but it is worth pointing out that this range is

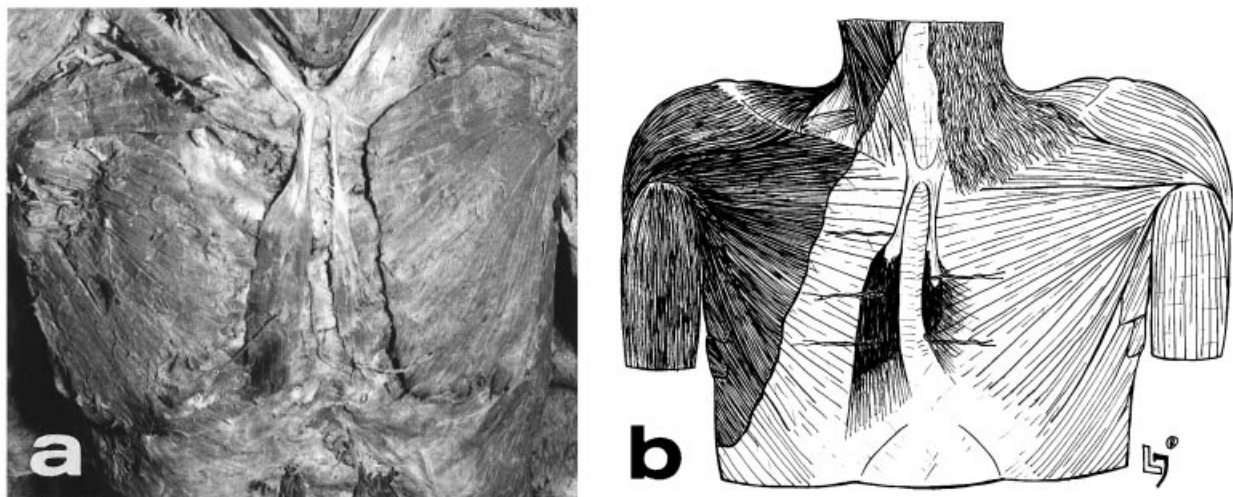


Fig. 1. Photograph (*a*) and schematic en face view (*b*) of the described bilateral sternalis muscle (type II2). In *b*, the pectoral fascia has been partly removed from the right side of the trunk.

Table 1. Frequency of sternalis in the subpopulations of the geographic races¹ from a review of the literature

Geographic race	Subpopulation	Author, year	Material (living persons; cadavers; adults or fetuses)	Number of bodies examined	Number of bodies with sternalis found	Frequency per bodies examined (%)	Number of thoracic halves examined	Number of thoracic halves with sternalis found	Frequency per thoracic halves examined (%)
European	English	Wood, 1866–67		175	7	4.0	350	8	2.3
	Scottish	Turner, 1867		650	21	3.2	1300	30	2.3
	Irish	Macalister, 1875		350	11	3.1			
	Irish	Cunningham, 1888		358	16	4.5	716	20	2.8
	Irish	O'Neill & Folan-Curran, 1998	adults	over 200	1				
	French	Le Double, 1890		809	37	4.6	1618	58	3.6
	French	Larget, 1914*		14	1	7.1			
	Alsations	Schwalbe & Pfitzner, 1894					338	11	3.3
	Belgian	Colson, 1886***		110	4	3.6			
	Italian	Calori, 1888		160	4	2.5			
	Italian	Romiti & Sylvestri, 1894*		81	8	9.9			
	Portuguese	Tavares, 1926–27***		265	5	1.9			
	Portuguese	De Pina, 1928**		295	10	3.4			
	Portuguese	Bruto da Costa, 1950		1000		7.4			
	Russian	Gruber, 1860		95 (!)	5	5.3	192 (!)	8	4.2
	Bulgarian	Jelev et al. 2001 (current study)	adults	102	3	2.9	204	4	1.96
	Greeks	Kumaris, 1903		100	'at least 3'				
	White American	Christian, 1898	adults	70	2	2.9	140	4	2.9
Asiatic	White American	Barlow, 1935	adults	251	16	6.4			
	White Brazilian	Locchi, 1930		125	8	6.4	250	10	4.0
	Japanese	Adachi, 1897	living	200	30	15.0			
	Japanese	Koganei, et al. 1903	adults				152	8	5.3
	Japanese	Adachi, 1909	adults	183	27	14.8	366	38	10.4
	Japanese	Matuchima, 1927***	adults	77	12	15.6	154	15	9.7
	Japanese	Taniguchi, 1930*	adults	204	22	10.8	408	30	7.4
	Japanese	Futai, 1931	adults	117	12	10.3	234	16	6.8
	Japanese	Nii, 1931***	adults	117	12	10.3	234	16	6.8
	Japanese	Taniguchi & Tochihara, 1932	fetuses	300	37	12.3	600	45	7.5
	Japanese	Hoshiba, 1936	adults	140	10	7.1	280	11	3.9
	Japanese	Watanabe, 1942	living	1012	41	4.1	2024	48	2.4
	Japanese	Morita, 1944	adults	205	21	10.2	410	27	6.6
	Korean	Tanabe, 1936***		101	13	12.9	202	17	8.4
	Chinese	Nakano, 1923*		32	7	21.9	64	10	15.6
	Chinese	Wagenseil, 1927*	adults	18	2	11.1	36	3	8.3
			fetuses	27	2	7.4	54	2	3.7
	North Chinese	Sakima, 1932***		34	8	23.5	68	11	16.2
	North Chinese	Fukuyama, 1940	adults	214	39	18.2	428	48	11.2
			fetuses	71	8	11.3	142	9	6.3
African	Taiwanese	Shen et al. 1992	adults	80	1	1.3	160	2	1.3
	Taiwanese	Jeng & Su, 1998	adults	207	2	1.0	414	4	1.0
	Filipinos	Yap, 1921	adults	136	5	3.7	272	8	2.9
			fetuses	10	2	20.0	20	4	20.0
				24	1	4.2			
African	African	Chudzinski, 1873		7	1	14.3	14	1	7.1
	African	Le Double, 1897		58	7	12.1			
	African	Loth, 1912***		91	12	13.2	182	13	7.1
	Black Brazilian	Locchi, 1930		91	12	13.2			
	Black American	Barlow, 1935	adults	284	17	6.0			
Indic	Indian	Misra, 1954	adults	150	6	4.0	300	7	2.3
	Indian	Rao & Rao, 1954	adults	64	3	4.7	128	4	3.1
	Indian	Kacker, 1960	adults	75	6	8.0	150	9	6.0
Australian Oceanic									
American									
Indian									

¹ The geographic races are given according to The New Encyclopædia Britannica (Gwinn et al. 1993).

* Cited by Taniguchi & Tochihara (1932); ** Cited by Barlow (1935); *** Cited by Fukuyama (1940).

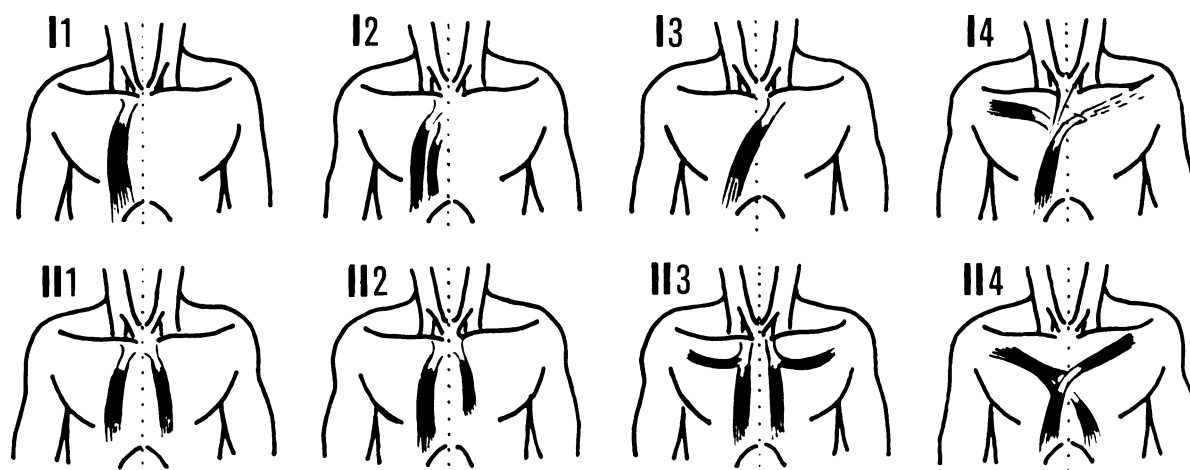


Fig. 2. Classification scheme for sternalis based on a review of the literature.

very wide, as shown in Table 1. Additionally, some authors have reported a general frequency for the sternalis: 3–4% (Kadanoff, 1954), 5% (Last, 1972) and 3–5% (Bergman et al. 1988).

Obviously, all the above data show that there exists great variation in the reported frequency of sternalis in the literature. An important reason for this discrepancy (especially concerning the frequencies in the subpopulations) may be the existence of small, ill-defined muscles or tendinous fibres which may or may not be accepted for a sternalis muscle. We therefore suggest that for a sternalis muscle to be accepted as a uni- or bilateral muscle, it should have the following characteristics, irrespective of length and thickness: (1) location between the superficial fascia of the anterior thoracic region and the pectoral fascia; (2) origin from the sternum or infraclavicular region; (3) insertion onto the lower ribs, costal cartilages, aponeurosis of the external oblique abdominis muscle or the sheath of rectus abdominis; (4) innervation by the anterior thoracic (pectoral) and/or intercostal nerves. On the basis of the morphology of the muscle bellies of the sternalis muscles so far reported, we offer a classification depicted as a scheme in Figure 2 with a description of the muscle types in Table 2. It is the first one in the literature. According to this classification, the 3 sternales detected by us in Bulgarians can be classified as type I1 (2 muscles) and type II2 (1 muscle).

Although sternalis has been investigated since its first description in 17th century, the problem of its genesis still remains a mystery. Different authors have assumed sternalis to be derived from neighbouring muscles: pectoralis major (e.g. Abraham, 1883; Dzialis, 1968; Kida & Kudoh, 1991), rectus abdominis (e.g. Blees, 1968; Larsen, 1997), sternocleidomastoid (e.g. Rao & Rao, 1954; Blees, 1967), panniculus carnosus (e.g. Barlow, 1935; Shen et al. 1992) and obliquus externus abdominis (Testut, 1884). In the present work, sternalis was found to be covered by the superficial fascia of the anterior thoracic region, a finding formerly reported only by Blees (1967). For that reason, a derivation of sternalis from the panniculus carnosus cannot be excluded. From a theoretical standpoint, it may be important to establish the innervation in every case of a

crossed sternalis muscle (type I3 and type II4). This would permit a decision as to whether such a muscle represents 2 fused muscles or a unilateral muscle, partly transposed to the contralateral side.

Sternalis is not only a rare muscle variant; it may have important clinical significance. During routine mammography, sternalis may be visible as an irregular structure medially on the craniocaudal projection and can give rise to diagnostic confusion with a breast cancer (Bradley et al. 1996). It may be excluded by CT or MR imaging (Bradley et al. 1996). It is interesting to note that the frequency of sternalis muscle established by these authors in women using radiographic imaging ($\sim 0.01\%$) is very different from the sectional frequency of women given by Barlow (1935). The rarity of sternalis found in the above radiological investigation could be explained not only by the more common unilateral occurrence of this muscle (Barlow, 1935; Bailey & Tzarnas, 1999) so that it is often unrecognisable on mammography, but also by a possibly real lower frequency in females. Because of difficulty in its detection, the presence of sternalis established in routine mammography must be recorded in the medical documentation of the patient for its eventual use in operative procedures. For the numerous operations on the breast (especially in mastectomy for breast cancer), it is important to have a knowledge of the structures of the anterior thoracic region. During a surgical operation the detection of a muscle, which is situated along the sternal margin and above the pectoral fascia should not surprise the surgeons as is reported often to be the case (Vandeweyer, 1999). This muscle must rightly be appreciated and eventually used in breast reconstruction (Bailey & Tzarnas, 1999). Because sternalis has an insignificant function on the anterior thoracic wall (Paturet, 1951; Jeng & Su, 1998) it may be used as a pedicle flap or flap with microvascular anastomosis in the plastic and reconstructive surgery of the head and neck region.

In the literature, sternalis muscle is called a 'normal anatomic variant' (Bailey & Tzarnas, 1999) and a 'well-known variation' (Kida et al. 2000) although in most textbooks of anatomy it is insufficiently mentioned. This muscle should be widely described in anatomy texts and atlases as is done in Gray's Anatomy (Bannister et al. 1995).

Table 2. Description of the types of sternalis

Type of muscle	Author, year
Type I: unilateral sternalis muscle	
I 1: simple unilateral belly	Turner, 1867 von Bardeleben, 1876 Hesse, 1876 von Bardeleben, 1888 Schultz, 1888 Fick, 1891 Kumaris, 1903 Yap, 1921 Futai, 1931 Patten, 1933–34a, b Slobodin, 1934 Morita, 1944 Misra, 1954 Rao & Rao, 1954 Kitamura et al. 1985 Vandeweyer, 1999 Kida et al. 2000 Jeleu et al. 2001
I 2: 2 or more unilateral bellies	Turner, 1867 Morita, 1944
I 3: muscle belly crossing the median line	Turner, 1867 Fukuyama, 1940 Morita, 1944
I 4: unilateral belly passing into another muscle or into well-defined muscle bundle of this muscle:	
m. preclavicularis medialis	Bryce, 1899 Blees, 1968
m. sternocleidomastoideus	Wallace, 1886 von Bardeleben, 1888 Kumaris, 1903 Yap, 1921 Futai, 1931 Morita, 1944 Misra, 1954
m. pectoralis major	Futai, 1931 Morita, 1944
Type II: bilateral sternalis muscle	
II 1: 2 simple symmetric bellies	Christian, 1898 Yap, 1921 Morita, 1944 Rao & Rao, 1954 Jeng & Su, 1998
II 2: 2 simple asymmetric bellies	Turner, 1867 von Bardeleben, 1888 Schultz, 1888 Kumaris, 1903 Yap, 1921 Futai, 1931 Morita, 1944 Kida & Kudoh, 1991 Shen et al. 1992 Jeng & Su, 1998 Jeleu et al. 2001
II 3: 2 bellies connected with pectoralis major on the same side	von Bardeleben, 1876 O'Neill & Folan-Curran, 1998
II 4: 2 bellies: one-simple unilateral and the other-connected with both the left and the right pectoralis major muscles	Calori, 1888

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